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Current state, Improvements and Latest Trends in Coal Preparation in Poland

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1. Introduction

Poland is the largest coal producer in Europe. In 2014 the coal output of steam coal amounted to 60.3 million tonnes and 12,3 million tonnes of coking coal. Poland also has the largest coal resources. They amount to 52.0 billion tonnes (resources supposed economic), but the amount of economic reserve base is deemed to be 3.7 billion tonnes.

The developed deposits amount to 19.8 billion tonnes (resources supposed economic) including 3.7 billion tonnes deemed to be economic reserve base. Steam coal resources amount to 11.6 billion tonnes (resources supposed economic), and 2.2 billion tonnes are deemed to be economic reserve base. However, coking coal resources amount to 8.1 billion tonnes resources supposed economic, of which 1.5 million tonnes are deemed to be economic reserve base. (Minerals Yearbook of Poland 2015). Recoverable resources of Poland are located up to the depth of 1250-1300 m. Coal extraction is conducted at depths from 400 to 1050 m.

Coal can be found in two regions in Poland (fig.1). These are the Upper Silesian Basin and the Lublin Basin (Balance of minerals 2015; Blaschke & Baic 2013).

The Upper Silesian Coal Basin (GZW) is the largest coal mining centre in Poland. The most productive coal deposits are within mine-field boundary of the coal mines. Coal has been mined in this area for over 300 years. Coal seams with thickness most convenient for mining and located in good mining and geological conditions have already been

mostly mined. The Basin constitutes. The Basin constitutes a single entity together with the Ostrava-Karvina area (in the Czech Republic). The entire surface area of the basin is about 5,400 km^2 of which 4,450 km^2 lies in Poland. In the productive series, the seams are 1.0-1.5 m thick, but some seams reach thickness ranging from a few meters to more than a dozen meters.

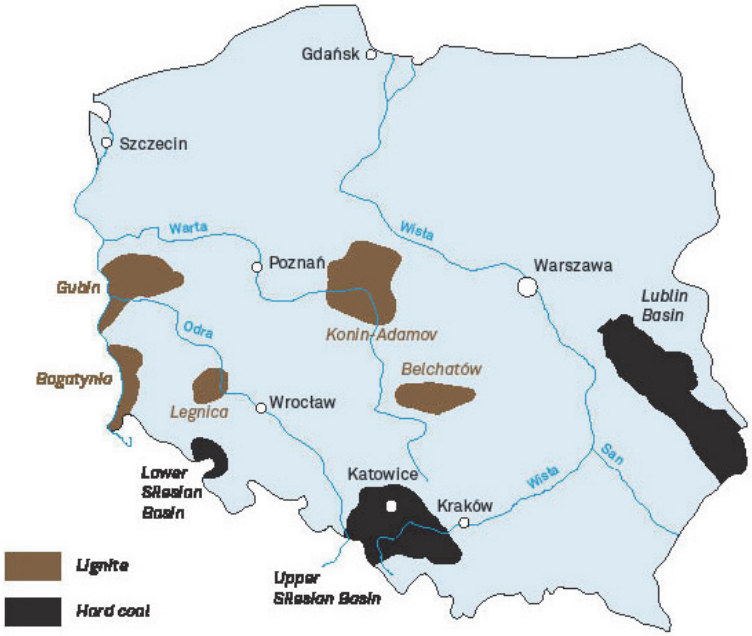

Fig 1. Occurrence of hard coal deposit in Poland
Rys. 1. Lokalizacja zasobów węgla kamiennego w Polsce

The Lublin Coal Basin (LZW), located in the east of Poland, covers an area of 4,630 km^2. It is about 180 km long and 20-40 km wide. The depth of bedding of seams does not exceed 750 m. The productive series contains more than ten seams (up to 18). The thickness of the seams ranges from 0.8 to 2.5m (and rarely more than 3 m).

The Lower Silesian Coal Basin (DZW) is about 60 km long and 30 km wide. The northern part of the Basin belongs to Poland and the southern part to the Czech Republic. There are up to 50 coal seams in the Basin and they mainly contain coking coal. Coal was once mined from

four mines, but due to a very difficult mining and geological conditions and very high costs of coal mining, the mining of coal reserves in this Basin has been abandoned.

In the Upper Silesian Coal Basin the following coal companies operate (the status as in a mid of 2015):

- Kompania Węglowa S.A. (up to 01.05.2016 Polish Minnig Group) – with its coal mines: „Jankowice", „Chwałowice" „Rydułtowy – Anna", „Marcel", „Bolesław Śmiały", „Piast", „Halemba – Wirek", „Bielszowice", „Ziemowit", „Pokój", „Sośnica";
- Katowicki Holding Węglowy S.A. – with coal mines: „Mysłowice-Wesoła", „Murcki-Staszic", „Wieczorek", „Wujek";
- Węglokoks Kraj Sp. z o.o. – with coal mines: „Piekary", „Bobrek";
- Jastrzębska Spółka Węglowa S A. – with coal mines: „Borynia-Zofiówka-Jastrzębie", „Budryk", „Krupiński", „Pniówek", „Knurów-Szczygłowice";
- Turon Wydobycie S.A. – with coal mines: „Sobieski", „Janina", „Brzeszcze";
- LW „Bogdanka" S.A. – operating on one mine.

There are exist also the following small mines:

- PG„Silesia" Sp. z o.o. – property of a Czech coal company;
- Siltech Sp z o.o. – private mine;
- ECO-PLUS Sp. z o.o. – private mine;
- Spółka Restrukturyzacji Kopalń S.A. – preliminarilly aimed for liquidation of unprofitable coal mines, nevertheless currently operates 4 mines: „Centrum", „Makoszowy", „Mysłowice", „Kazimierz Juliusz", for which there is no final decision about their future.

2. Basic Production Statistics

2.1. Overall coal production (5 year trend)

The coal production in the Poland has been decreasing for the past five years. As shown in Table 1, coal production over the last 3 years (2012-2014) has decreased 9% from nearly 79.2 million tons to 72.5 million tons. Further reductions of 4-6% are forecast for next year (2016).

Table 1. Production data for Polish Coal Industry
Tabela 1. Wydobycie węgla w Polsce

Year	2011	2012	2013	2014	2015
Total production [Mg]	**75 668 000**	**79 234 000**	**76 466 000**	**72 514 000**	**72 193 000**
Steam coal [Mg]	64 232 000	67 496 000	64 351 000	60 226 000	59 208 000
Coking coal [Mg]	11 436 000	11 738 000	12 115 000	12 288 000	12 985 000

Table 2. Structure of steam coal production
Tabela 2. Struktura produkcji węgla energetycznego

Year	2011	2012	2013	2014	2015
Steam coal [Mg]	**64 232 000**	**67 496 000**	**64 351 000**	**60 226 000**	**59 208 000**
Coarse coals	6 770 000	5 957 000	6 214 000	5 164 000	4 441 000
Medium size coals	2 842 000	2 541 000	2 719 000	2 317 000	2 191 000
Fine coals	52 558 000	57 846 000	53 679 000	51 644 000	51 333 000
Others	2 061 000	1 152 000	1 738 000	1 101 000	1 243 000

Table 3. Sale data for Polish Coal Industry
Tabela 3. Sprzedaż węgla w Polsce

Year	2011	2012	2013	2014	2015
Total sale [Mg]	**76 215 000**	**71 936 000**	**77 496 000**	**70 305 000**	**73 556 000**
Steam coal [Mg]	64 945 000	60 538 000	64 938 000	57 998 000	60 607 000
Coking coal [Mg]	11 270 000	11 398 000	12 558 000	12 307 000	12 949 000

2.2. Washed production

Approximately 60% of the Polish coal production is washed with some form of coal preparation. The saleable coal has the following quality parameters:

- coking coal – ash content varies from 5.4% to 8.8% (average 6.8%) and sulphur content varies from 0.51% to 0.89% (average 0.67%);
- steam coal for the power industry – the net calorific value ranges from 15.4 kJ/kg to 25.4 kJ/kg, ash content ranges from 9.9% to 30.1% (average 22.4%) and sulphur content from 0.56% to 2.59% (average 0.83%).

In Poland some power stations are adapted to burn raw coal (non-prepared coal) – its net calorific value can be 19.2 MJ/kg, and sometimes even less whereas the ash content can be up to 26%, and the sulphur content of 1.57%.

2.3. Number of plants

Coal companies	Number of CPP	Capacity [tph]	Range of size mm	Washed production [million Mg]	Type/Distribution of circuits
Kompania Węglowa S.A. (Polish Mining Group S.A.)[1)]	20	600-2,100	20-0 (85 %) >20 (15%)	~14.4	vibration screens, jaw crushers (20), dense medium washer (18), grain jigger (2), jig washer (14), dense medium cyclone (1), hydrocyclone (6), spirals separator (4), flotation (7)
Katowicki Holding Węglowy S.A. [1)]	5	600-1,600	20-0 (78 %) >20 (22%)	~3.2	vibration screens, jaw crushers (5), dense medium washer (5), jig washer (1)
WĘGLOKOKS KRAJ Sp. z o. o.	2	1,500	20-0 (90 %) >20 (10%)	~0.5	vibration screens, jaw crushers (2), dense medium washer (2), jig washer, Barrel washer (2)
JSW S.A.	8	800-1,600	20-0 (98 %) >20 (2%)	~12.3	Bradford drum crushers, dense medium washer (8), jig washer (8), flotation (8)
TAURON Wydobycie S.A.	2	900	20-0 (80 %) >20 (20%)	~2.9	vibration screens, jaw crushers (2), dense medium washer (2), jig washer (2), spirals separator (2)
LW "Bogdanka" S.A.	1	2,400	20-0 (85 %) >20 (15%)	~7.4	vibration screens, jaw crushers (2), dense medium washer (2), jig washer (2)
PG "Silesia" Sp. z o. o.	1	575	20-0 (82 %) >20 (18%)	~1.2	vibration screens, jaw crushers (1), dense media washer (1), dense medium cyclone (1)
TOTAL	**39**	**~ 1,000**	**-**	**~41.9 (~60%)[2)]**	**vibration screens, jaw crushers (40), dense medium washer (38), grain jigger (2), jig washer (29), dense medium cyclone (2), hydrocyclone (6), spirals separator (6), flotation (15)**

1) estimates data
2) depends on quality of raw fine coal and demands quantity of energy producers

3. Significant Industry Changes in Last 3 Years

3.1. Technological, Environmental + Economic Developments

The main changes in last 3 years: (Blaschke el. al. 2010, Baic & Witkowska 2011, Baic 2013)

- setting in order and improvement of particular process circuits:
  - reconstruction of the raw coal preparation station,
  - modernisation heavy-media separation system,
  - modernisation of the jig wash,
  - elimination of the flotation concentrate drying plant,
  - construction of a flocculator measurement installation,
  - modernisation of the dispatcher system,
  - modernisation of the dust separation system,
- implementation of more efficient dewatering technologies for fine coal to improve the quality of the products and maximise the reduction of slimes disposal outside the water-slurry circuits,
- modern arrangements for preparation of power mixtures,
- up to date instrumentation of key technological circuits with electronic monitoring measurement equipment:
  - construction of electronic samplers for saleable coal,
  - construction of electronic analysers for qualification of basic qualitative parameters.

3.2. Impact on coal preparation segment in future

Quality parameters of coal depend of properties of seems being worked, coal quality in seems and applied exploitation system. Extraction of coal in future from mining reserves off deep coal seems increasing impurities in ROM and changing legal environment regulation, obligatory control of parameters of solid fuels undertaken by government are the main factors which have a major impact on coal preparation sector.

4. Improvements

4.1. Research & Development Needs (Blaschke & Szafarczyk 2013)

- Developing new analyzers of ash, sulphur and moisture contents, which are more accurate for measuring on clean coal, middlings and wastes.

- Automation and process control systems for devices of coal preparation technologies to increase productivity and efficiency.
- Developing a new method to achieve a quick and accurate date of characterization of coal quality in terms of washability.
- Improving dewatering of finest grains coal (below 0,063 mm) to reduce the load on closed water-slurry systems.
- Introduction to industrial practice dry coal cleaning technology (deshaling) on FGX series compound (Baic 2015, 2015a).
- New alternative utilization waste of mining.

4.2. Efficiency

Technological possibilities of reducing the cost of preparation through the implementation of CMMS (Computerised Maintenance Management System) and PIMS (Production Information Management Systems), which includes: area of forecasting the quality of production, planning and integration of the extraction process with the preparation and sales process.

4.3. Productivity

Further activities for mechanization and automation of operations and processes in order to reduce labour expenses and improve process performance.

4.4. Safety

- reduce the risks related to exposure to harmful and dangerous factors by reducing the emission of noise, dust, vibration, etc. derived from the use of machines and other means of production,
- reducing the exposure time of these factors on workers.

4.5. Water Usage

- further reduce water consumption by simplifying the water-slurry circuits
- improving the efficiency of processes especially clarifying water, thickening and dewatering of products,
- reduction of water losses related to the operation of the settling ponds,

- reduction of the duration of wet processes limiting the grains contact with water,
- use of the underground water as the medium for conducting wet processes in a closed water-slurry system,
- implementing of dry separation technology of raw coal.

5. Plant Design

Actually many preparation plants in many cases are modernized. The main goals are to improve and modernize the entire coal processing technology (transport systems, enrichment in jigs washer, enrichment in dense medium washer etc.) for ensuring production high quality coal.

5.1. Typical circuits (Blaschke 2000, Blaschke & Gawlik 2006)

A typical technological flow sheet of washing +20 mm steam coal is presented in fig. 2. while fig. 3 presents the flow sheet of a modern plant for washing and desulfurization of fines. A typical technological flow sheet of coking coal washing is presented in fig. 4.

5.2. Latest trends

- replacement of thermal drying for mechanical dewatering, which reduce the emission of dust and gases into the atmosphere and consumption of coal or other fuels for their own needs or to reduce employment,
- automation of coal preparation process for the regulation parameters enrichment, changing transport system and method for storing (system of selective storage saleable coal),
- increased production of environmentally friendly coal,
- employment optimization,
- automation and visualization of production processes to help reduce employment and cost of processing.

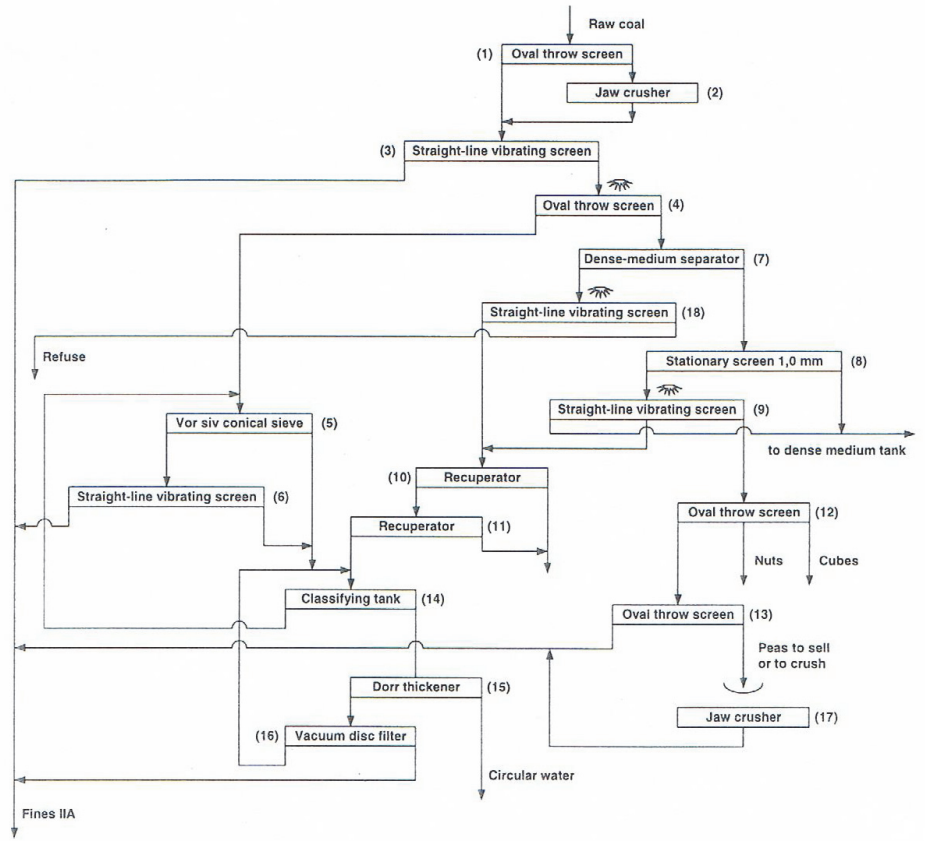

Fig. 2. Flow sheet of steam coal preparation plant
Rys. 2. Schemat technologiczny zakładu przeróbki węgla energetycznego

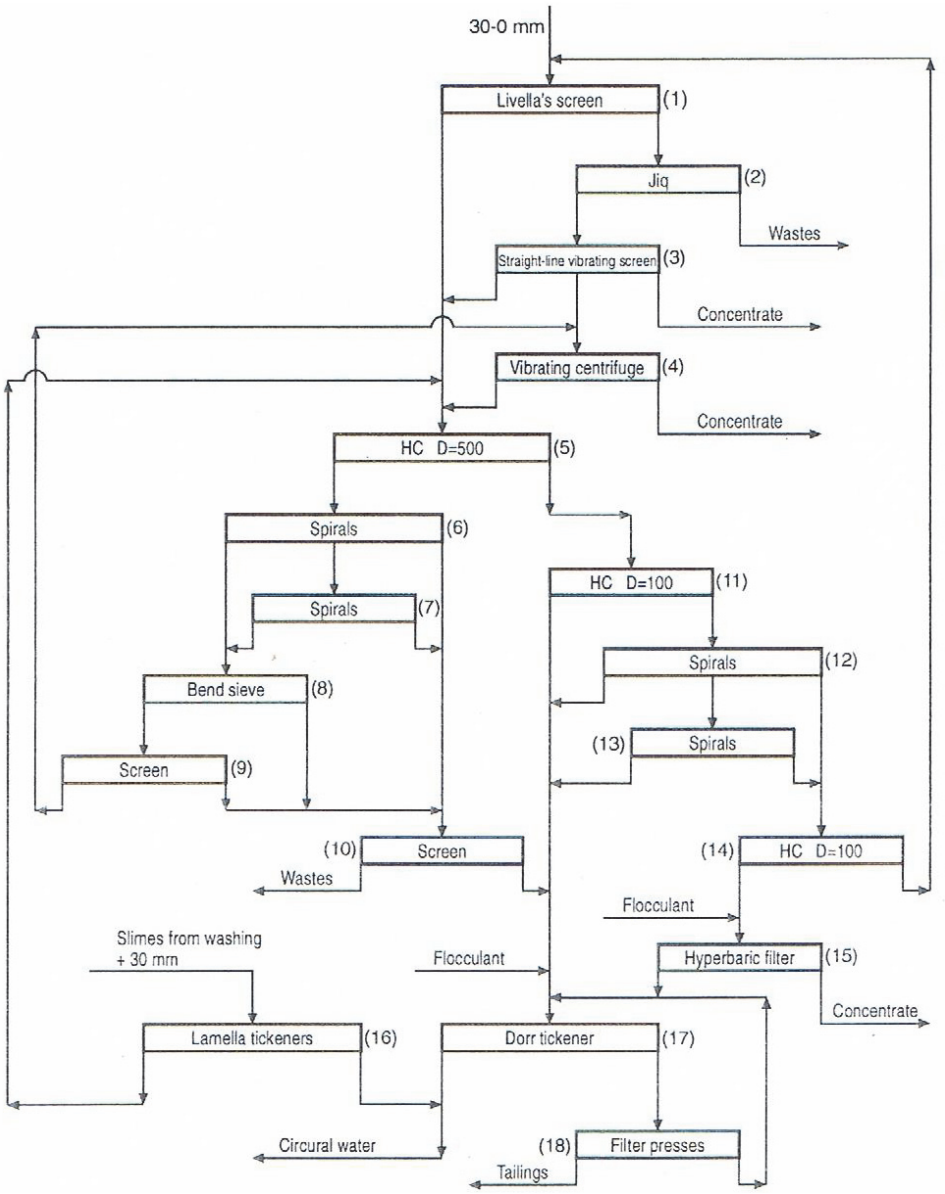

Fig. 3. Flowsheet of coal fines preparation and desulphurization process
Rys. 3. Schemat technologiczny zakładu wzbogacania i odsiarczania miałów węglowych

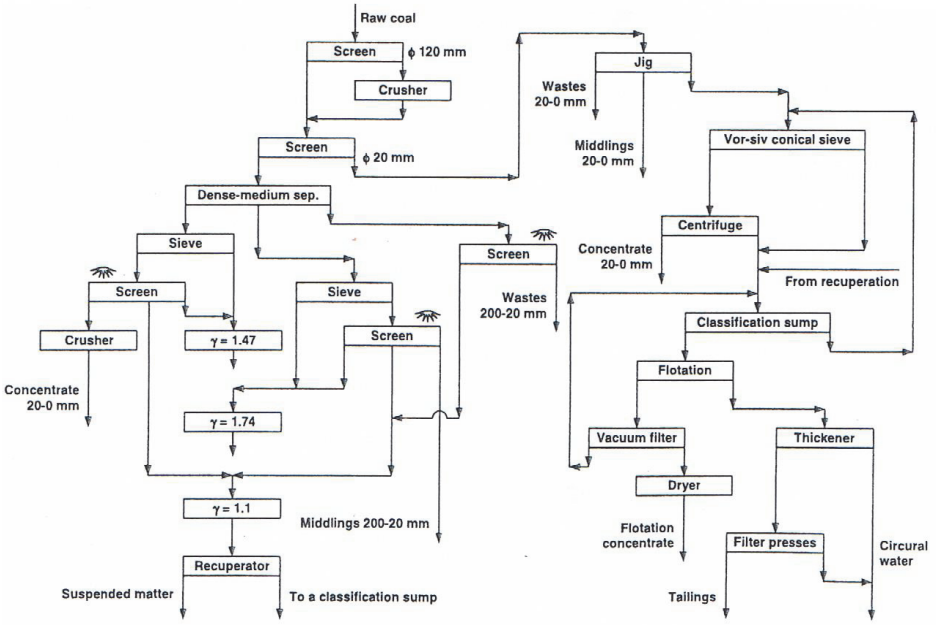

Fig. 4. Flowsheet of the coking coal preparation plant
Rys. 4. Schemat technologiczny zakładu przeróbki węgla koksowego

6. Conclusions

Coal preparation plants existing in the mines fulfil their task with regard to efficiency and technology. However, they require successive modernisation activities and investments to improve particular process circuits and reduce production costs. There is need to improve coal quality monitoring and stability of the feed quality and products of coal preparation with particular attention paid to the variety of marketable grades.

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Stan aktualny, modernizacje oraz najnowsze trendy w przeróbce węgla w Polsce

Streszczenie

W artykule przedstawione zostały informacje o występowaniu węgla kamiennego w Polsce. Omówione zostały dwa zagłębia węglowe, w których obecnie prowadzona jest eksploatacja podziemna węgla kamiennego: Lubelskie Zagłębie Węglowe (LZW) i Górnośląskie Zagłębie Węglowe (GZW). Dla tych zagłębi węglowych zaprezentowane zostały dane o obszarze, budowie geologicznej oraz o typach i średnich parametrach jakościowych eksploatowanych węgli (zawartość popiołu, zawartość siarki, wartość opałowa itp.). W artykule przedstawiono również dane odnośnie produkcji, struktury oraz wielkości sprzedaży węgla kamiennego w Polsce w latach 2011-2015, a także wielkości produkcji pod-

danej wzbogacaniu oraz ilości zakładów przeróbki węgla z informacja o wydajności i rodzaju zastosowanych urządzeń. Zaprezentowano także wykaz istotnych zmian w zakładach przeróbki węgla w okresie ostatnich trzech lat z podziałem na technologiczne, środowiskowe i ekonomiczne. W artykule zamieszczono również wykaz niezbędnych do wdrożenia udoskonaleń w obszarze: rozwiązań technologicznych, efektywności, produktywności, bezpieczeństwa oraz zużycia wody. Zaprezentowano również obecne trendy w wzbogacaniu węgla.

Na tym tle przedstawiono również problemy związane z przeróbką węgla kamiennego w Polsce. Opisane zostały schematy technologiczne typowych zakładów przeróbczych (w Polsce funkcjonują różne układy technologiczne wzbogacania węgla energetycznego i koksowego). Omówiono wzbogacanie węgli grubych, średnich i drobnych.

Abstract

The article presents information on the occurrence of hard coal in Poland. Two coal basins are described, in which underground coal mining is currently taking place: the Lublin Coal Basin (LZW) and the Upper Silesian Coal Basin (GZW). For these two coal basins, general information is given concerning geological resources and their structure, as well as the types and average quality properties of the extracted coal. The paper also presents data on the production, structure and sale data for Polish Coal Industry in 2011-2015, washed production and number of coal preparation plant with capacity and type of circuit. It also presents a list of significant changes in coal preparation plants in the past three years in terms of: technological, environmental and economic. The article also contains a list of necessary improvements in the area: technology, efficiency, productivity, safety, and water consumption. Also presented the last trends in the enrichment of coal

On the background of this information some issues of hard coal preparation in Poland are presented. Technological layouts of typical preparation plants are shown (in Poland, different technological systems are used for preparation of steam coal and coking coal). Beneficiation of large, medium and fine coal is discussed.

Słowa kluczowe:
produkcja węgla kamiennego, zasoby węgla kamiennego, węgiel energetyczny, węgiel koksowy, wzbogacanie i odsiarczanie miałów węglowych

Keywords:
coal production, coal resources, steam coal, coking coal,
preparation and desulphurization of fine coal